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Seizing The Initiative: Maintaining the Vitality of Defense Laboratories In An Era Of Declining Defense Expenditures

Abstract

Superior technology yields victory on the battlefield with the minimum cost in human life. How we can retain the nation's military technological preeminence in the face of massive cuts to the defense budget is the subject of this paper. Increased private sector participation is offered as a way to strengthen public and congressional support for military lab funding, enhance national competitiveness, and benefit the military through the transfer of technology from commercial to military. This paper proposes aggressive marketing of DoD lab capabilities to increase participation in commercial development activities.

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Seizing The Initiative

Maintaining the Vitality of Defense Laboratories In An Era of Declining Defense Expenditures

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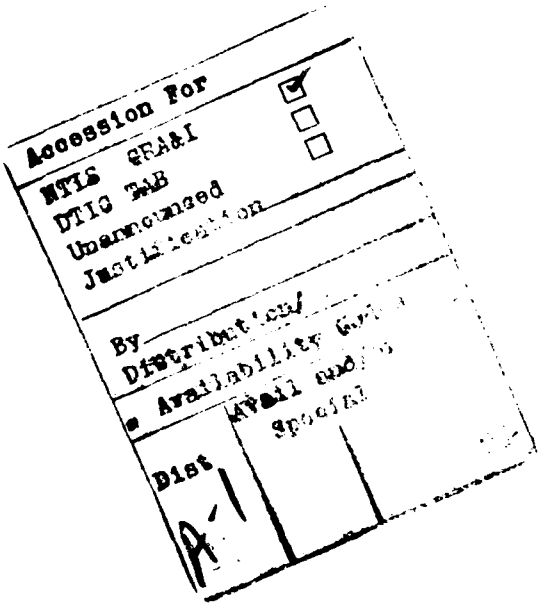

Introduction

This paper presents a concept to maintain DoD laboratories as a vital and productive element of nation's technology base. It calls for the aggressive involvement of DoD laboratories in the commercial sector and requires a willingness to change traditional roles and missions. To be successful the commercial sector must begin to view DoD labs as a reliable resource with the capability to contribute to the technological success of this nation. The military must come to understand that commercial involvement will enhance rather than dilute its scientific and technological base. Changes will occur. I propose the Department of Defense take the lead to propose logical and beneficial change.

Changes

If we can trust pre-election claims, the election of Bill Clinton to the presidency will result in a far more active role for government in technology. Like it or not the "winners" in our national technological community will be those who view this shift as an opportunity and not a problem as Giulio Douhet said

> "Victory smiles upon those who anticipate the changes in the character of war, not upon those who wait to adapt themselves after the changes occur."[1]

The technological war of this nation and, indeed, this world has been joined by an administration no longer willing to depend on market pressures to direct technology investment. According to the Washington Post the "Clinton Plan"[2]:

- Puts the vice president in charge of technology issues.
- Shifts more funds from defense to non-defense R&D programs.
- Rapidly increases federal lab joint ventures with industry.
- Creates 170 manufacturing extension centers, up from seven.
- Creates new civilian counterpart to defense research agency.

Within the Department of Defense it would be easy to see the shift in funding in the plan as a problem, but our success depends on viewing these problems as opportunities. For example, must a shift of funds from defense to non-defense R&D programs mean less for defense related research? The past success of defense research makes a strong case for building on this foundation rather than tearing it down. Building on this foundation requires an understanding of our past strengths and of the changes required to succeed in the new environment.

A New Paradigm

Times of relative plenty in the 1980s allowed the DoD to pursue technology with little regard to potential domestic applications. In discussing what he calls the myth of spinoff John Alic contends four factors complicate the application of military technology to meet commercial needs:[3]

- Separation of defense and commercial sectors of U.S. industry limits opportunities and raises the costs of spinoff.

- Proper accounting of the investments required to adapt a defense innovation to commercial use belies the nōtion of spinoff as a cost-free benefit of government technical effort.
- In refusing to target technology investments based on their commercial importance or potential, only technologies relevant to the mission needs of federal agencies (primarily aerospace and electronics) are developed.
- The efficiency of such spinoff investments in producing commercial technology needs to be compared to alternate types of federal investment.

We can no longer can expect to pursue technology in a military vacuum. Tomorrow's investments in military technology must yield tangible and measurable benefits to the commercial sector. If not, we run the real risk of the military technology budget being sacrificed to pay for ventures that directly benefit commercial. Given the prevalent thought, if we force a "guns or butter" decision it will be at the expense of the guns. To compete successfully for technology dollars we must strive for this to be a "guns **and** butter" decision. How? One answer my lie in Clinton's plan to shift technology spending to non-defense programs. This plan will also "make it easier for industry to tap federal research facilities...and overcome conflict of interest laws that keep corporate executives from joining in formal discussions with government officials about how to strengthen U.S. competitiveness."[4]

Problem or Opportunity?

The new administration's increased focus on technology development provides a perfect opportunity to advocate DoD labs as a part of a national strategy to strengthen U.S. competitiveness. The Department of Defense has built a very large and capable

laboratory system. These laboratories helped produce the technology that has given us undisputed superiority in the battlefield. With the reduced threat to the United States we can no longer justify the expense of the laboratories based solely on military necessity. Boeing's senior vice-president of engineering and technology said, "We have developed in the USA an outstanding government laboratory system that has served us very well, but we have a major problem right now. That laboratory system was designed to advance and support our military system and, with peace breaking out they are running out of things to do."[5] Certainly we must cut the defense budget and some lab reductions and consolidations are required, but before we make irrevocable changes, I would like to consider an alternative and expanded use.

This alternative use is to broaden the mission of DoD labs to include an active role in commercial technology. To build the foundation for increased participation by DoD labs in the commercial sector this paper presents a threefold approach . First, we must convince the commercial sector that DoD labs can truly help. We must market labs by stressing past performance and emphasizing current research and development capabilities. Next we need to promote industry's use of these resources in a synergistic relationship. Finally, we must broaden the military mission and attitudes to include this new role for the military. Let's begin by looking at what DoD labs can offer the commercial sector.

Marketing Military Laboratories

What do we do better than anybody else in the world? Despite headlines that might try to convince you to the contrary. We build the best military hardware and have captured the greatest share of the world weapons' market. "The U.S. share of the total market was 44.8% in 1990, up from 23.6% in 1989."[6] It is technological superiority not cost that leads countries who can afford the best to buy U.S. Indeed, U.S. weapons are more "costly than most other Third World producers."[7] U.S. arms sales to Saudi Arabia approached $15 billion in 1990 and since August of 1990 and sales to the Middle East have topped $21 billion[8].

I am not proposing we seek to become the world's weapon supplier, but that we consider what yielded this advantage and why do we not see a corresponding lead in commercial technology. Contrary to popular thought our loss in commercial technological superiority does not stem from a lack of funding (Figure 1). The United States spends almost twice as much as Japan and Germany combined. What we do lack is a comprehensive strategy to efficiently apply all our nation's technology resources.

National R&D Spending Comparisons (Figure 1)[9]

Country	R&D Spending($B)	Defense R&D ($B)	R&D/GDP (Percent)	Nondefense R&D/GDP (%)
United States	134	43	3	2
Japan	47	0	3	3
FRG	25	1	3	3
France	18	4	2	2

Country	R&D Spending($B)	Defense R&D ($B)	R&D/GDP (Percent)	Nondefense R&D/GDP (%)
United Kingdom	17	3	2	2
Italy	9	1	1	1
Canada	6	0	1	1
Netherlands	4	0	2	2
Sweden	4	0	3	3
Switzerland	3	0	3	3
Non-U.S. Total	133	10	2	2

To achieve military technological superiority the nation applied a comprehensive strategy. We built a large defense laboratory infrastructure where trained scientists and engineers work in well equipped modern facilities. Military contracts allowed the recovery of industry research and development costs and guided industry efforts toward specific scientific pursuits. Defense programs also subsidized and rewarded industrial modernization and manufacturing technology improvements. Weapon system users determined requirements and reviewed progress during development while scientific advisory boards evaluated the research process and technical merit. This strategic investment and management experience in the DoD labs can now be applied to commercial technology development.

DoD labs are ready and able to harness tremendous national resources to address the national technological shortfall. Of the $150 billion annual national R&D effort, the federal government is responsible for 46.1% by source and 11.1% by performance. The

DoD is by far the largest consumer of our technology dollars spending over $37B in 1990 (Figure 2).

Federal R&D Obligations by Major Agency ($B)[10]

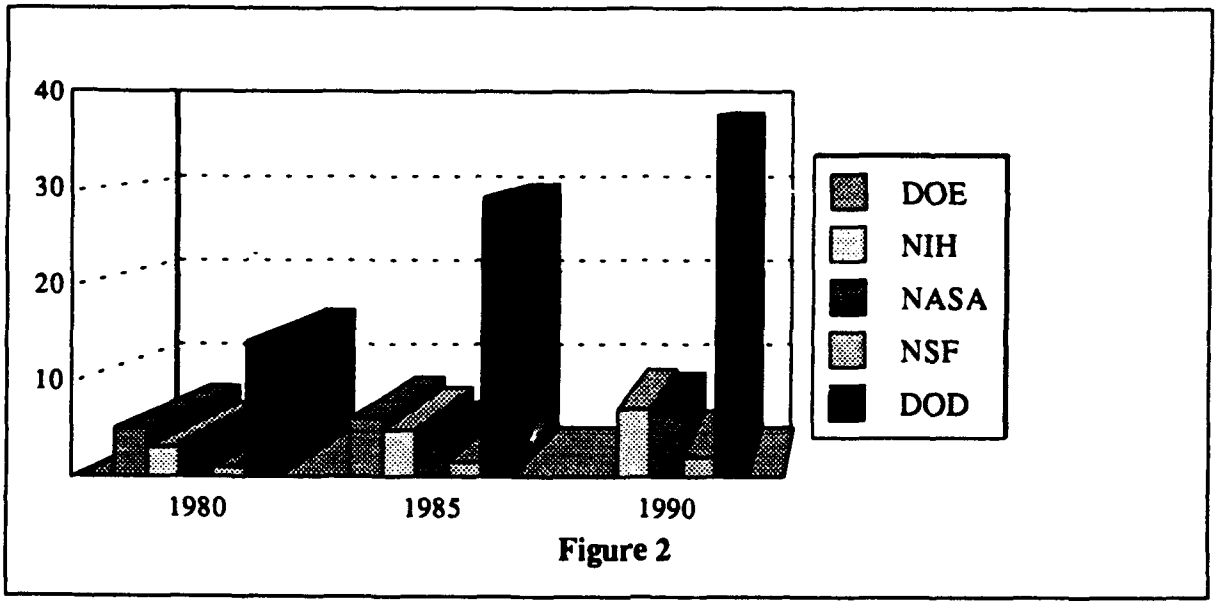

Figure 2

Time For Cooperation

The lines dividing military and commercial technology are increasingly blurred. A review of the defense, national, of commerce technologies (Table 1) yields great commonality and DoD labs are very active in every area. "Civilian and military technology are moving close together. More and more of the unclassified work done at universities and in industrial research laboratories has major military applications, while work performed at the government's national laboratories is moving more and more in the direction of civilian sector usefulness".[11]

Comparison of Critical Technologies Lists[12] (Table 1)

Technology	Defense Critical Technology	Commerce Emerging Technology	National Critical Technology
Composite Materials	Yes	Yes	Yes
Microelectronics	Yes	Yes	Yes
Superconducters		Yes	Yes
Flexible Manufacturing	Yes	Yes	Yes
Software	Yes	Yes	Yes
High Perf Computing	Yes	Yes	Yes
Data Fusion	Yes	Yes	Yes
Photonics	Yes	Yes	Yes
Sensor Technology	Yes	Yes	Yes
Simulation and Modeling	Yes		Yes
Biotechnology	Yes	Yes	Yes
Medical Technology	Yes	Yes	
Propulsion	Yes		Yes

Industry and government must recognize jointly applying the resources of the military labs serves their mutual interests. The Federal Technology Transfer Act of 1986[13] removed a number of barriers to cooperation by authorizing Cooperative Research and Development Agreements (CRADAs). "CRADAs permit government-operated laboratories to enter into agreements with private companies, universities, state and local governments, foundations, not-for-profit organizations and consortia of such groups."[14] The Director of the U.S. Department of Energy's (DOE) Los Alamos Laboratories hailed CRADAs as "the most popular vehicle for business interface"[15], but do they go far enough?

Speaking of DOE nuclear weapon laboratories, the Center for Strategic & International Studies noted "despite strong support for laboratory-industry consortia, joint R&D projects in critical technologies remain on the sidelines of the laboratories primary research missions and budget."[16] The Council on Competitiveness further criticized CRADAs stating "so far, very little technology that industry can actually incorporate has been forthcoming."[17] despite "an unprecedented overlap between the labs' technical capabilities and industry's needs."[18] To improve the ability of industry to incorporate the technology, future endeavors must be industry centered, rather than, government centered. That is to say we should pursue projects based on the potential benefit to industry and needs of the marketplace.

Opportunities for cooperation are increasing with diminishing differences between commercial and military technology. As commercial enterprises see the benefits of the productive involvement by the DoD labs, popular and, as a result, Congressional support for continued funding will increase. As the military gains technological innovation from the diversity of the market place they will increasingly pursue joint ventures. Attitudes will not change overnight, but with the correct approach partnerships with industry can become the hallmark continued U.S. leadership in military technology.

Teaming With Industry

A broader role for DoD labs in the commercial sector requires a basic shift in the customer/supplier relationship between the military and industry. According to Erich Bloch former head of the National Science Foundation and senior fellow on the Council on Competitiveness, "We should be much more straightforward about government funding of critical technologies, we should move the money where the problem is...we need to make use of the vast resources of the Pentagon laboratories."[19] Taking this one step further, my goal would promote DoD as the supplier of choice to meet our national technology needs. Rather than encouraging technology transfer from military to commercial, I propose the DoD begin to assist in the development commercial technology with an objective of transferring this technology from commercial to military. This is a major shift in the philosophy and operation of military and industrial relations. To be successful we must convince industry and government decision makers that we have the resources and ability to perform.

Facilities

Few realize the size of the DoD laboratory infrastructure with over 70 laboratories spanning the globe and participating in almost every research field imaginable (Appendix). In 1987 these labs spent approximately $6.3B. In-house efforts accounted for 40 and the remainder for industry and academia[20]. In addition, "the DoD has access to 10 Federally Funded Research and Development Centers (FFRDCs)...to

provide research and analytical support to OSD and the Services".[21] (Figure 3) Finally the DoD operates a number of test facilities that contribute to our ability to test, analyze, and fix our systems in development and beyond. These test centers employed over 22,000 personnel in 1987 and spent approximately $8.4B.[22] Together these agencies could provide tremendous resources to meet the challenge of fostering commercial technology.

DoD FFRDCs FY 1991 (Figure 3)[23]

R&D Laboratory	**$ Millions**
Lincoln Lab/USAF	436
Study and Analysis Centers	
RAND OSD/OJCS	29
RAND Project Air Force/USAF	26
Center for Naval Analyses/Navy	41
Institute for Defense Analysis/OSD	96
Logistics Management Institute/OSD	21
RAND Arroyo Center/Army	25
Systems Engineering/Systems Integration	
Aerospace Corporation/Air Force	418
MITRE C3I Division/Army/Air Force	427
Software Engineering Institute/DARPA	26
Institute for Advanced Technology/Army	1

People

An additional benefit to industry is the ability to tap in to a large and experienced scientific work force that supports this infrastructure. According to the vice-president of

TRW Space and Defense Division and former commander of Air Force Systems Command:

> We're looking at 100,000 people lost in 1991 (in the defense sector) and 35,000 this year already. Technology, as far as I am concerned, is people. And when those people leave, we're losing that technology; that's what I'm concerned about.[24]

The federal government employs approximately 800,000 of this nation's scientists and engineers. Counting defense contractor personnel, "nearly one third of U.S. scientists and engineers is employed in military work."[25] President Clinton has proposed assigning "top physicists from the defense labs to the research labs of corporations."[26] Perhaps we should leave these scientists and physicists within the proven defense system and increase their availability to industry. In this way we can provide better access to the nation and greater response to the national technology strategy.

Cost Sharing

To really "sell" this idea to industry DoD labs must be justified on the balance sheet. U.S. industry is struggling and the pressure to reduce cost is increasingly at odds with the need to invest in technological advancements. In 1991 spending for research, development, test and evaluation was down 6% from 1990 levels. [27] With spending down cooperative ventures offer industry increased leverage for their limited technology investment dollars. DoD can assist by bidding its cost on the margin. By allowing

existing defense research to assume fixed costs, DoD labs can become the low cost supplier by bidding the cooperative research at time and materials with no absorption of overhead. Though this may seem a radical proposal, the DoD stands to benefit in three ways. First the additional business helps fill the excess capacity resulting from the 9% decline (after adjusting for inflation)[28] in service R&D budgets since 1988. Second, serving the nation's industry increases the vitality of DoD labs and popular support for their need. Finally, the greatest benefit to this approach is that the market, by acquiring services, will direct research activities and judge their merit. If the market does not think a worthwhile contribution to research can be made by DoD labs it will not buy the service and the resources should be redirected.

The commercial to military spin-off from cooperative ventures will also benefit the military. Determining what projects to pursue requires a planned approach with pre-established goals and periodic evaluations. Each cooperative development program must be "good science" and support a potential military application. Technology development need not lead to a weapon system or military end item, but should advance the state of the art for potentially developing these items. The result will maintain a "warm" military technology base to contribute to system development when required.

Applying the resources of DoD laboratories to develop technology for the commercial sector is logical and efficient. Developing good business arrangements to

attract this cooperation is also possible and reasonable. Neither of these two is possible, however, without broadening traditional views of the military mission.

Redefining Roles

Using military labs to increase the competitive nature our nation's commercial industry requires a fundamental review of the military and its raison d'être. According to the National Military Strategy of the United States the military will:

> "Deter any aggression that could threaten the security of the United States and its allies and - should deterrence fail - repel or defeat military attack and end conflict on terms favorable to the United States, its interests and its allies."[29]

This role is no less required of our military, but it leads to a definition of our required military strength based solely upon external factors, the strength of an adversary. With the dissolution of the Soviet Union sizing the military in relativistic terms one concludes we must drastically cut the military and/or redefine military strategy in terms of the national interest.

On a de facto basis the redefinition of the military mission is already occurring. The military is involved in the drug war, domestic and international disaster relief, peace making, and peace keeping. These extra-military roles keep our military agile, active, and strong as we respond to the changing global paradigm of the New World Order. Ignored in the debate over the broadening military mission is a critical element to

our continued military superiority, technological superiority. Again looking at our National Military Strategy we see the increasing importance of technological superiority in peace and war.

> "The United States must continue to rely heavily on technological superiority to offset quantitative advantages, to minimize risk to US forces, and to enhance the potential for swift, decisive termination of conflict. In peace, technological superiority is a key element of deterrence. In war, it enhances combat effectiveness and reduces loss of personnel and equipment....We must continue to maintain our qualitative edge. Therefore, advancement in and protection of technology is a national security obligation."[30]

Viewing our required military strength solely in terms of our adversaries will not sustain the research and development that has provided our qualitative edge. The decreasing military budget and the shift in focus to commercial technology promised by the new administration will only exacerbate this situation. I propose an element of our national military strategy should include:

> Promote the economic, political, and military security of the United States through the advancement of technology of mutual benefit to our nation's defense and commercial sector.

Broadening the mission statement allows our political leadership greater freedom to employ the military to do more than just defeat an adversary in the battlefield. Redefinition is possible as indicated by the new vision statement of the U.S. Air Force "Air Force people building the most respected air and space force in the world...global reach, global power." This is a long way from the, albeit informal, mission I was first

introduced to, "To fly and to fight and don't you ever forget it." The old mission narrows perspective and limits flexibility while the new speaks to the qualitative aspects of the end result and inspires the imagination of the people pursuing it.

With declining defense research dollars now, more than ever, we need the imagination to seek creative ways to strengthen this nation's security. Technology is woven into the fabric of both our economic and military strength. Ideological barriers must not prevent DoD laboratories from contributing to both. With the proper perspective the coming changes can be opportunities not just to maintain, but to improve our defense technology by becoming part of a broader national technology strategy.

Where To Begin

I have no doubt the military labs can contribute technological innovation, but true progress will require a well structured national program. A successful program must begin with a comprehensive strategy and focused leadership. It is time Defense Advanced Research Projects Agency (DARPA) to assume a broader leadership role in the commercial sector. According to a professional staff member of the House Armed Services Committee the critical technologies lists of the Department of Commerce and the Department of Defense are 80% in common. He further stated the Department of Commerce does not possess the infrastructure to manage a national technology program. DARPA should be tasked to act as a policy coordinating committee with the services

and industry to plan and guide a national strategy to improve military and commercial technology.

This strategy should target specific research areas and the agencies to coordinate the national effort. Along the way we should constantly evaluate whether our approach and strategy meets industry's needs. This list below presents one plan to assure our strategy effectively address industry needs[31]

- Developing an information base for diagnosing and monitoring the technological competitiveness of various industries
- Increasing the financial attractiveness of innovational efforts by individual firms.
- Reducing certain risks to the realization of expected innovational benefits.
- Increasing the array of promising innovational opportunities.
- Encouraging needed increases in basic research and the entry of more scientists and engineers into hitherto neglected industrial sectors.
- Strengthening governmental capabilities for evaluating technological improvement needs and progress.

Such a list could provide an outline for a national technological strategy of which the military would play a large part. National monitoring and reporting could provide the progress of efforts and report information. Sharing cost through a marginal cost policy enhances the financial attractiveness of investment by commercial firms. The sharing of cost is a sharing of risks and should encourage innovation. A national strategy that targets critical industry and the participation of DoD labs can ensure entry into "hitherto neglected industrial sectors." The final item on this list "strengthening

governmental capabilities for evaluating technological improvement needs and progress" is the key to match the capabilities of military labs with the needs of our commercial sector.

In this paper I have elaborated on only one element of that strategy, the increased commercial involvement of DoD labs. An overarching national strategy would determine where and precisely how this involvement would occur. Some initial ideas might be found in the International Defense Review's list of readily available military related markets for industry and government. "First subsea commercial developments...secondly, long-term storage and preservation of defense equipment...and third the relationship between defense and the environment."[32] Specifically this list includes

Subsea commercial developments	U.S. Domestic bases (clean-up)
Oil and gas	Magazine Storage
Telecommunication and power	Underground Storage
Defense	Industrial buildings
Fishing and mariculture	Dehumidification techniques
Marine biotechnology	Protective Materials
Non-petroleum based mineral resources	Management of depots
Recreation and leisure	Storing munitions and explosives
Waste Management	Defense and environment
Transport and salvage	Corrosion
Storage and preservation of defense equipment	U.S. Redeployment within NATO
Defense industry in Eastern Europe	German clean-up

Such a list provides areas ripe for military labs to quickly demonstrate their expertise. In addition to these immediate targets of opportunity, there is virtually no industry with which the military does not possess the potential to contribute (Appendix).

Conclusion

The defense industrial base is rapidly eroding to a point where it may not meet the demands of this nation. These demands are not merely a desire to have superior technology, but are much more fundamental to the American psyche. America has a very low tolerance for death in warfare. The media delayed several years into World War II before showing dead American and the "living room" war of Viet Nam gradually weakened our resolve to continue. As a patriotic and even jingoistic country we are sometimes too willing to accomplish our objectives through military intervention as long as none of our soldiers get hurt. In Desert Storm our sophisticated weaponry allowed the U.S. to win a decisive victory without large numbers of casualties. Our nation bought this technological advantage with a substantial and long standing commitment to research.

The nation is now decreasing its investment in national defense, but not its demands. We are asking our military to do more missions with this decreased funding. Unfortunately during this time of economic pressure to cut the military budget the world is not becoming a safer place. The potential for conflict is increasing with spreading

nationalism and the reemergence of historic ethnic rivalries. Future conflicts will involve increasing sophisticated weapons as countries, including the U.S. proliferate their advanced weapons. With the quick victory of Desert Storm, the American public will be even less tolerant to the loss of life or an extended conflict in the inevitable next military action.

This strategy presented by this paper expands traditional roles and missions and applies the military as a broader instrument of the national will. National disaster assistance, foreign and domestic peace keeping and drug interdiction are wholly consistent with the expanding military mission. The military can also contribute to the economic strength of this nation by targeting and developing technology of benefit to the commercial sector. The pursuit of mutually beneficial technology contributes to the vitality and viability of the military labs while sharing their efforts as a national resource. We must all participate in solving the economic problems of this nation. With the proper approach, participation by the military is tremendous opportunity to meet the national needs and maintain our technological edge. The military has a proud record of accomplishments and tremendous resources to contribute. It's time to seize the initiative.

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APPENDIX

Army Laboratories	Primary Area Of Responsibility	Military Personnel	Civilian Personnel	Funding ($M)
Army Materiel Command Laboratory	**Atmospheric Science Lab:** Development Of Technology To Measure And Predict Weather At The Operational And Tactics Level And Quantifying Atmospheric Effects On Warfighting Systems And Capabilities.	58	403	43.02
	Ballistic Research Lab: R&D In Establishing And Maintaining Weapons Oriented Basic Research In Defense Related Technologies And Conducting Research Into The Vulnerability And Lethality Of Army Weapons.	17	718	46.79
	Electronic Technology And Devices Laboratory: Primary Lab For Electronics, Electron Devices, And Tactical Power Supplies. Lead For Very High Speed Integrated Circuits And Microwave/Millimeter Wave Monolithic Integrated Circuit Programs.	1	318	44.43
	Harry Diamond Laboratory: R&D In Areas Including Electronic Fusing, High Power Microwaves, Radar Technology, Target Recognition, And Recognition And Information Signal Processing. Lead For Studying The Nuclear Effects On Various Battlefield Systems.	3	679	129.5
	Human Engineering Lab: Lead For Man-Machine Interface For Army Advanced Systems. Lead For Robotics And Human Factors Engineering.	35	174	29.25
	Materials Technology Lab: Managing And Conducting R&D In Materials And Solid Mechanics, Including Basic Research In Advanced Metals Composites And Ceramics.	21	588	48.4
	Vulnerability Assessment Laboratory Assesses The Susceptibility And Vulnerability Of U.S. Army Weapons And C3I Systems To Hostile Electronic Warfare And Electromagnetic Effects.	5	255	29
Army Materiel Command's Research, Development And Engineer Centers	**Armament R D E Center** Concentrates Its Efforts On Two Main Areas, Weapons And Munitions. This Center Works In Such Areas As Laser Protection , Electric Gun, Smart Munitions And Liquid Propellant Guns. Operates Benet Laboratory Which Conducts R&D Related To Recoilless Rifles, Motor Weapons, And Cannons For Tanks, Towed And Self Propelled Vehicles.	88	3,978	328.299
	Chemical R D E Center Lead For Chemical And Biological Defense Related Matters. Ensures Capability To Operate In A Contaminated Battlefield.	99	1,160	136.76
	Aviation R D E Center Is Responsible For Army Aviation Research And Development Including Airframes, Propulsion Systems, And Avionics.	105	1,271	122.51
	Communications-Electronics Command R D E Center C3I Is Responsible For Research In The Areas Of Command, Control, Communications, Intelligence And Electronic Warfare. Includes A Center For Night Vision To Develop For Night Vision And Target Acquisition. Center For Signal Warfare Conducts Programs Related To Surveillance, Reconnaissance, And Electronic Warfare. Center For Command Control And Communications Conducts R&D Into Army Unique C3I Needs.	149	1,493	280.89
	Missile Command R D E Center Is Responsible For Development, Acquisition, And Production Of All Army Missile Systems. Lead For Guidance And Control, Terminal Homing, And High Power/High Energy Laser Technology. Capable Of Carrying A Concept Through To Prototype Almost Without Outside Help.	53	1,305	109.93

Army Laboratories (Cont'd)	Lab/Center And Specific Area Of Responsibility	Military Personnel	Civilian Personnel	Funding ($M)
Army Materiel Command's Research, Development And Engineer Centers (Cont'd)	**Tank And Automotive Command R D E Center** Is Responsible For Technologies And Systems Associated With Vehicular Propulsion, Structure, And Advanced Armor. Substantial Exploratory Work Underway With Robotics Vetronics And Survivability.	29	786	109.93
	Belvoir R D E Center Is Responsible For Combat Engineering, Logistics Support, Materials, Fuels, And Lubricants.	59	1,002	140.233
	Natick R D E Center Is Dedicated To Ensuring The Maximum Survivability, Supportability, Sustainability, And Combat Effectiveness Of The Individual Soldier In Combat. Conducts R&D Into Air Drop And Combat Service Support, Food Engineering And Service Equipment, Combat Clothing And Individual Equipment.	98	934	60.55
Office Of The Surgeon General	**Aeromedical Research Laboratory** Performs Research In The Areas Of Acoustics, Vision, Crew Workload And Stress, Vibration Impact Studies And Life Support Technologies.	69	67	6.88
	Institute Of Dental Research Conducts Basic And Applied Research Leading To The Methods And Materials For Improved Management Of Combat Maxillofacial Injuries And To Provide The Soldier With Dental Support In A Combat Environment.	58	18	4.35
	Institute Of Surgical Research Investigates Problems Of Mechanical And Thermal Injury And The Complications From Such Trauma. Includes Care Of Patients With Such Injuries, Studies And Training Of Physicians And Medical Personnel In Managing Thermal Injuries.	155	78	18.13
	Letterman Army Institute Of Research Provides A General Medical Research Capability And Conducts Research In Dermal Protection Against Biological And Chemical Hazards, Combat Casualty Injuries And Treatment, Biomedical Effects Of Military Lasers, Blood, And Blood Substitutes And Mammalian Toxicology.	142	99	18.13
	Medical Bioengineering R&D Laboratory Focuses On The Protection Of Soldiers In Combat And Training Scenarios, Employees In Army Unique Industrial Exposure Settings And The Environment.	29	91	10.97
	Medical Research Institute Of Chemical Defense Is The Army's Lead Laboratory For Development Of A Medical Defense Against Chemical Warfare Agents.	85	158	12.18
	Medical Research Institute Of Infectious Diseases Serves As A R&D Lab For The D O D To Develop Vaccines Against Potential Biological Warfare Agents.	293	187	7.26
	Research Institute Of Environmental Medicine Conducts Research On The Effects Of Temperature, Altitude Work And Nutrition On The Health And Performance Of The Individual Soldier Or Combat Crews Operating Army Systems.	72	81	104.12
	Walter Reed Army Institute Of Research Performs Research In The Areas Of Military Disease Hazards, Combat Casualty Care, Army System Hazards, And Medical Chemical Defense.	433	547	104.12
Corps Of Engineers	**Cold Regions Research And Engineering Laboratory** Investigates Problems Faced By The Corps Of Engineers In Cold Areas. Researches Such Areas As Effects Of Cold And Ice On Various Military Equipment.	253	32	7.17
	Construction Engineering Research Laboratory Conducts R&D In Facility Construction, Operations And Maintenance. Analyzes Approaches For Land Restoration And Energy Conservation For New	3	212	34.42

Army Laboratories (Cont'd)	Lab/Center And Specific Area Of Responsibility	Military Personnel	Civilian Personnel	Funding ($M)
Corps Of Engineers (Cont'd)	**Engineer Topographic Laboratories** Provide The R&D In Topographic Sciences (Mapping, Point Positioning, Geographical Information) And Terrain Analysis.	15	324	63.13
	Engineer Waterways Experiment Station Includes Five Labs--Hydraulic, Geotechnical, Structures, Environmental, And Coastal Engineering Research Center. Supports Military And Civilian Mission Of The Army Other Federal Agencies And Allied Nations.	10	1,607	58.36
Deputy Chief Of Staff For Personnel Research Institute For Behavioral And Social Sciences	This Is The Lead Lab For The Soldier Oriented Research	30	313	61.16

Navy Laboratories	Primary Area Of Responsibility	Military Personnel	Civilian Personnel	Funding ($M)
Naval Research Laboratory Washington, D.C.	Computer Science, Artificial Intelligence, Information Management, Electronic Warfare, Materials, Directed Energy Weapons, Surveillance And Sensors, Space Systems	97	3,576	219.97
Naval Oceano- Graphic And Atmospheric Research Laboratory Bay St Louis, Ms	Ocean Sciences, Ocean Acoustics, Atmospheric Sciences	26	434	49.76
Naval Air Development Center Warminister, Pa	Aircraft And Aircraft Systems Including Electronic Warfare And Antisubmarine Warfare. Science And Technology Programs Include Electro-Optic, Acoustic, And Microwave Technologies For Surveillance And Targeting	236	2,723	258.1
Naval Ocean System Center San Diego, Ca	Ocean Surveillance Systems (Acoustic, Electromagnetic, Etc.). Artificial Intelligence, Knowledge Based Systems To Support Combat Decision Aid Programs. S&T Activities Include Ocean Science, Bioscience, And Electronics.	272	3,125	306.77
Naval Weapons Center China Lake, Ca.	Air-To-Air Weapons, Anti-Radiation Missile Technology, Sensor Technology (Infrared, Electro-Optic) And Missile Engineering.	506	5,427	384.78
David W. Taylor, Naval Ship Research And Development Center Carderock, Md	Hull Designs And Advanced Ship Protection Systems, Model For Surface And Submarine Propulsion. S&T Includes Acoustics, Magnetics, Materials And Structures, Hydrodynamics, Advanced Propulsion And Ship Survivability.	66	2,771	225.18
Naval Surface Warfare Center White Oak, Md -	Weapons And Systems For The Detection And Attack Of Surface And Subsurface Targets. S&T Includes Energetic Materials, Charged Particle Beams, And Sensors.	100	5,038	294.8
Naval Undersea System Center Newport, Ri	Advanced Developments In Sonar And Other Undersea Detection Technologies.	80	3,667	229.76
Naval Coastal Systems Center	Mine Countermeasures, Shallow Water Undersea Weapons. R&D Into Torpedo And Sonar Countermeasures, And Ship/Airborne Mine Countermeasures.	133	1,225	67.72
Air Propulsion Center Oakland, Ca	R&D Of Airbreathing Propulsion Systems And Development And Evaluation Of New Propulsion Systems.	7	730	37.33
Civil Engineering Laboratory Port Huenene, Ca	R&D For Shore And Fixed Surface And Subsurface Ocean Facilities And Construction Forces. Sponsors Activities In Environmental Protection, Alternative Energy Sources, And Deep Ocean Pressure Vessels.	18	425	31.99
Clothing And Textile Research Facility Natick, Ma	R&D And Engineering Support In Clothing Textiles And Related Fields Associated With Navy Clothing And Environmental Protective Clothing.	1	65	3.455
Personnel Research And Development Center San Diego, Ca	Principal R&D Center For Personnel, Education, And Human Factors Analysis.	28	310	22.598
Aerospace Medical Research Laboratory Pensacola, Fl	R&D And Evaluation In Aviation Medicine And Allied Sciences To Enhance Health And Safety And Readiness Of Aviation Personnel.	38	55	4.75
Biodynamics Laboratory New Orleans, La	Biomedical Research On The Effects Of Motion, Vibration And Impact Encountered In Ships And Aircraft By Navy Personnel	34	45	3.16
Dental Research Institute Gre	R&D In Dental And Allied Sciences With Emphasis On Concerns Of Navy And Marine Personnel, Fleet And Field Dentistry.	22	15	1.28

Air Force Laboratories	Primary Area Of Responsibility	Military Personnel	Civilian Personnel	Funding ($M)
Armstrong Laboratory San Antonio, Tx	**Human Resources Lab:** R&D Of Advanced Development Programs For Manpower And Personnel, Operational And Technical Training, Simulation And Logistics Systems.	191	214	57.95
	Armstrong Aerospace Medical Research Laboratory: Development Of Protective Equipment, Study Of Human Physical And Mental Performance For Effective System Integration, Identification And Quantification Of Chemical Hazards Created By Air Force System And Operations.	120	156	48.69
	School Of Aerospace Medicine: R&D Into Disease Detection, Aircrew Medication, Treatment Of Disease And Effects On Mission Operations, Aerospace Biotechnology, And Aerospace Medicine.	280	254	21.7
Wright Laboratory Dayton, Oh	**Aeropropulsion Lab**: Exploring And Developing Technologies Associated With Aircraft And Aerospace Vehicle Power, Including Turbine Engines, Ramjets, Aerospace Power Components, Fuels And Lubricants.	57	325	147.9
	Avionics Lab: Development Of Avionics Systems And Technologies. Major Efforts In Microelectronics, Microwave Devices, Advanced Electro-Optics, Target Recognition Technologies, Radar Systems, And Electronic Warfare.	147	554	313.66
	Flight Dynamics Lab: Aerodynamics, Aircraft Design, Aerospace Structures Including Complex Composites, And Flight-Control Systems Such As Fly-By-Light Systems, Investigations Into Advanced Flight Mechanisms Including Hypersonic Flight, Short Take-Off And Landing, And Advanced Maneuvering Technologies.	168	613	167.8
	Materials Lab: Materials R&D Including Electronic And Electromagnetic Materials, Metals, Composites, And Superconductor Materials. Nondestructive Evaluation Programs To Develop Advanced, High Strength, Low-Weight Structures For Aircraft And Aerospace Systems.	52	299	156.36
Phillips Laboratory Albuquerque, NM	**Weapons Lab:** Lead In Nuclear Weapons Effects, Directed Energy Weapons, And Radiation Hardening Technologies. Close Association With DOE Sandia And Los Alamos Labs.	580	537	325.46
	Astronautics Lab: R&D For Interdisciplinary Space Technology And Rocket Propulsion.	157	281	379.97
	Geophysics Lab: Developing And Deploying Space, Airborne, And Ground Based Systems. Research Is Conducted Into Atmospheric Science, Earth Sciences, Infrared Technology, Space And Terrestrial Environment.	117	450	103.39
Rome Laboratories Griffiss, AFB, NY	Investigation Into Advanced C^3 Concepts, Information Processing, Ground Based And Strategic Surveillance Systems. Works In Electromagnetic And Solid-State Sciences. Antennas And Electromagnetic Phenomena, Solid State Electronics, Materials And Systems.	206	1,056	379.97
Engineering And Services Laboratory Tyndall AFB, FL	Basic R&D, Advanced Development, And Selected Engineering For Civil Engineering And Environmental Quality Technology.	68	38	22.71
Frank J. Sieber Research Laboratory A.F. Academy, Colorado Spring, CO	Basic Research In Electrochemistry Of Molten Salts, Energetic Materials, Theoretical Chemical Calculation And Unsteady Dynamics.	23	9	2.24

Navy Laboratories (Cont'd)	Primary Area Of Responsibility	Military Personnel	Civilian Personnel	Funding ($M)
Health Research Center San Diego, Ca	Fleet Operational Readiness Through Evaluation Of Health Risks For Navy Occupations, Human Performance, Effectiveness, And Physiological Adaptation During Sustained Operations.	22	15	1.28
Medical Research Institute Bethesda, Md	Basic And Applied Research And Development Concerned With Health Safety And Efficiency Of Navy And Marine Personnel. Research In Combat Casualty Technology, Wound Healing, Septic Shock, Tissue Transplantation, And Environmental Stress.	260	192	19.57
Medical Research Unit, No. 2 Manila Phillipines	R&D For Diagnosis And Treatment Of Infectious Diseases Of Military Importance And Endemic In The Area.	27	48	2.74
Medical Research Unit, No. 3 Cairo, Egypt	R&D Related To The Health Safety And Readiness Of Navy Personnel Assigned To Southwestern Asia And Africa.	29	205	5.07
Submarine Medical Research Laboratory Groton, Ct	Medical R&D As It Relates To Submarine, Shipboard, Diving And Amphibious Environments	29	52	4.44
Total	**All Navy Laboratories**	2,140	30,185	2,182

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